The Income Cliff in Households: Insights from Agent-Based Computational Modelling

André Grow & Jan Van Bavel

Centre for Sociological Research, University of Leuven (KU Leuven), Belgium

Manuscript prepared for the 2017 conference of the European Sociological Association in Athens, Greece

Acknowledgements

The research leading to these results has received funding from the European Research Council under the European Union's Seventh Framework Programme (FP/2007-2013)/ERC Grant Agreement no. 312290 for the GENDERBALL project. Eurostat, the European Commission, and the national statistical offices collecting the data have no responsibility for the results and conclusions which were drawn in this paper on the basis of the European Union Statistics on Income and Living Conditions data. An earlier version of this paper has been presented at the 2017 conference of the International Network of Analytical Sociologists in Oslo, Norway.

Abstract

In Western countries, the distribution of relative incomes within marriages tends to be skewed in a remarkable way. Husbands usually do not only earn more than their wives, but there is a striking discontinuity in their relative contributions to household income at the 50/50 demarcation line: many wives contribute less than or almost as much as their husbands, but few contribute more. This 'cliff' has been interpreted as evidence that men and women avoid situations where the wife would earn more than her husband, since this would run against traditional gender norms. In this paper, we use agent-based computational modelling to demonstrate that the cliff in the relative-income distribution can also emerge without such avoidance. We feed our computational simulations with income data from 27 European countries. Results show that a cliff can emerge from differences in men's and women's average incomes, even if they do not attach special meaning to a situation in which a wife earns more than her husband.

Keywords

Marriage markets, income, partner preferences, households, gender inequality, agent-based computational modelling

Introduction

Women's labour market opportunities have improved dramatically since the mid of the 20^{th} century. Starting in the 1960s, women have entered higher education in ever greater numbers and nowadays they often outperform men in terms of enrolment and success in tertiary education (Schofer and Meyer 2005). This increase in educational attainment was paralleled by an increase in female labour force participation and an influx of women into previously male dominated occupations of high status (Cha 2013). Because of these changes, some scholars have expected marriage to become increasingly gender egalitarian, meaning that spouses would become more and more similar in their labour force participation and contributions to the economic wellbeing of their families (e.g., Oppenheimer 1988; Torr 2011; Jalovaara 2012).

There is evidence that the economic roles that men and women hold within their families have indeed become more similar over time (Sweeney and Cancian 2004; Torr 2011; Goldscheider et al. 2015). However, marked gender differences still exist in most areas of life (Esping-Andersen 2009; England 2010; Ridgeway 2011; Bailey and Diprete 2016), also when it comes to the financial contributions that men and women make to their families (Bertrand et al. 2015; Klesment and Van Bavel 2017). Men do not only provide a larger share of the household income, but there is a remarkable discontinuity at the 50/50 demarcation line. Figure 1 illustrates this for unions (married or unmarried cohabitation) among people age 25–45 years in 27 European countries. It shows the distribution of couples according to the share of the household income that the woman provides. In most countries, the distribution steeply increases up to the point where the woman provides close to 50% of the household income. After this point, there often is a sharp drop and there are fewer unions in which the woman contributes more than the man.

–Figure 1 about here–

Bertrand et al. (2015) argued that standard economic models of partner search cannot account for such a 'cliff' in the distribution of relative incomes within households. According to Bertrand et al. (2015), if income is a positive criterion for partner selection, there is no reason to expect the distribution of relative incomes to change abruptly at the 50/50 point. In their words, "if matching is positive and income is the attribute of interest, a woman in the 30th percentile of women's income distribution will match with the man who is in the 30th percentile of men's income distribution. Whether the woman earns more or less than the man in absolute terms has no significance in these models" (Bertrand et al. 2015, p. 581). Thus, the fact that there is a discontinuity at the 50/50 point might indicate a social norm that "a man should earn more than his wife" (Bertrand et al. 2015, p. 612).

The observed discontinuity in the distribution of relative income within households at the 50/50 point would be consistent with a norm that favours a male-breadwinner role, if such a norm exists. However, in this paper, we argue that such a norm is not necessary to generate the observed discontinuity. Instead, we suggest that the observed cliff is fully compatible with standard partner search models, if we consider that even in the most gender egalitarian societies women's average income is lower than men's.

Our argument is based on the following intuition. As Bertrand et al. (2015) have pointed out, standard partner search models suggest that if people strive for high income partners, men who rank high in the male income distribution will tend to partner with women who rank high in the female income distribution. Some men might therefore form unions with similar-income partners, but because women's average income is lower, many men will face a shortage of partners with similar or even higher income. Unless they are willing to remain single, these men will have to form unions with women who earn less than they do. Women, by contrast, will have to 'settle' less often for a lower-income partner. These differences in men's and women's marriage market opportunities are likely to not only create a right skew in the distribution of women's contribution to household income, but also a discontinuity at the 50/50 point. This occurs even if people are not more aversive of a situation in which the wife out-earns her husband than of a situation in which he earns more.

We demonstrate the logical consistency of our argument with a simulation study, in which we compare the outcomes of several marriage market models. Our models are based on earlier research in economics and sociology and assume that people have a positive preference for income in their partners that is the same for men and women. For simplicity, the models assume that income is the only mate selection criterion. This means that when confronted with two spousal alternatives who differ in their income, people prefer the one with the higher income. The models differ in their specific assumptions about partner search, but none of them assumes that there is a norm that a husband should earn more than his wife. We submit each model to computational simulation experiments which we initialize with empirical income data for the 27 European countries shown in Figure 1. In our analyses of the empirical distributions of incomes within households, we include both marriage and unmarried cohabitation. Across Europe, cohabitation has been on the rise in recent years and in some countries is attaining a status similar to marriage (Hiekel et al. 2014); for simplicity, we use the term 'marriage' in the remainder of this paper and by that refer to both union types.

Our results show that differences in the earnings between men and women can not only lead to a right skew but also to a discontinuity in the relative income distribution. This happens in the absence of a male-breadwinner norm. In fact, our results show that standard marriage market models would imply an even stronger discontinuity than can be observed empirically. Our results thus support our argument and our work adds to research that cautions against inferring preferences and social norms from aggregate-level mating patterns (e.g., Grow et al. forthcoming; Kalick and Hamilton 1986; England 2004; Smaldino and Schank 2011; Grow and Van Bavel 2015).

Modelling marriage markets

Observed heterosexual marriage patterns are commonly assumed to derive from two-sided partner search on a marriage market (Willekens 2010). This notion holds that both men and women are searching for a spouse among the available alternatives of the opposite sex. Their search is guided by a set of preferences for the characteristics that their partner should have, but the realization of these preferences is constrained by the composition of the marriage market. If there is a shortage of alternatives with the desired characteristics, the opportunities to find the 'ideal' mate are limited, and people somehow need to adjust to this reality. These adjustments can take different forms, such as widening and prolonging search, settling for a partner who is less than ideal, or even foregoing marriage altogether (England and Farkas 1986; Oppenheimer 1988).

Determining which social processes have generated observed marriage patterns is often difficult, and it can be misleading to infer people's partner preferences from aggregate marriage patterns, because very different preferences can lead to very similar patterns (Smaldino and Schank 2011; Van Bavel and Grow 2016). For example, over the last decades, the share of marriages in which the husband is more educated than the wife has decreased, and the share of marriages in which she is more educated has increased. This might result from changing cultural norms, which in the past held that a man should have a higher socioeconomic status than his wife (cf. Esteve et al. 2012). However, the same changes in educational pairings can result from the fact that in the past women were on average less educated than men, but nowadays tend to be more educated. Today, there simply are fewer possibilities for women to partner with somebody who is more educated, even if they wanted to (Grow and Van Bavel 2015). Similarly, it is well known that the high correlation of physical attractiveness ratings within couples which has often been observed in empirical research (e.g., Berscheid et al. 1971) can result from a preference for partners with similar attractiveness, but also from the competitive pressures that a preference for very attractive partners creates (Kalick and Hamilton 1986).

Agent-based computational modelling makes it possible to deal with some of the challenges that the study of two-sided partner search processes poses (Willekens 2010; Zinn 2016). With this approach, researchers make explicit assumptions about the preferences and constraints that guide people's partnering decisions. These assumptions are then implemented in formal models, which are submitted to computational simulations of partner search in potentially large and heterogeneous populations. By varying the assumptions that underlie the behaviour of the artificial agents at the micro level, it is possible to explore theoretically whether different preferences and behaviours can lead to similar–or different–marriage patterns at the macro level (Billari et al. 2003; Todd et al. 2013; Van Bavel and Grow 2016). Here, we make use of this approach to demonstrate the logical consistency of our argument.

We consider several models that differ in their specific assumptions about partner search, but that all assume the same country-specific marriage market structures. In each country, there are 1,000 men and 1,000 women (to which we also refer as male and female 'agents'), who are searching for a spouse. Each agent has a fixed annual income, y, which they are randomly assigned based on the country- and gender-specific income distributions among married people age 25–49 years, as observed in the 2007 and 2011 waves of the European Union Statistics on Income and Living Conditions (EU-SILC). Figure 2 shows these distributions for each of the 27 national marriage markets that we consider. As can be seen from this figure, women's average income is lower than men's in all countries. There are also relatively more women than men with no income, but fewer women with high incomes.

–Figure 2 about here–

In the remainder of this this section, we present three different models which we develop in a step-wise fashion. We start from a classical matching model that has frequently been used in economic research on marriage markets. The second and the third model relax some of the simplifying assumptions that this model makes, based on insights from research in sociology and social psychology, to reflect crucial aspects of two-sided partner search processes more realistically. We submit each of the three models to systematic simulation experiments and discuss the outcomes that they generate.

An economic matching model

Economists who study marriage markets often have a particular interest in stable marriage matchings. A stable matching is achieved when "there is no married person who would rather be single [… and] there are no two (married or unmarried) persons wo prefer to form a union [with each other]" (Weiss 1997, p. 100). The interest in stable matchings derives from the presumption that marriage assignments that do not satisfy both conditions will either not form or are likely to dissolve (Weiss 1997). Hence, the study of stable marriage matchings makes it possible to describe the marriage patterns that we might expect if the marriage market would be in a stable equilibrium. This provides a useful starting point for our analysis.

Gale and Shapley (1962) pioneered research on two-sided matching by describing an algorithm that can generate stable matchings in any market. In developing this algorithm (from here on also called the *GS-algorithm*), the authors were agnostic as to which characteristics matter for partner selection. They simply assumed that both men and women can assign each member of the opposite sex a subjective utility that they expect to derive from marrying this particular person, and that people can rank all available alternatives according to this utility in descending order. Gale and Shapley (1962) also assumed that the utility that people expect from any marriage is higher than the utility from remaining single, so that they always prefer being married over being single. Finally, they assumed that the members of one sex (say men) decide to whom they want to propose marriage, whereas the members of the other sex (say women) decide which proposals to accept. Based on these assumptions, the following iterative partner selection process leads to stable matchings; the resulting pattern can differ when women get the opportunity to propose and use different partner selection criteria than men, but the result is the same when men and women positively value the same characteristics in a partner, no matter members of which sex gets to propose (Weiss 1997).[1] We assume that both men and women value income positively and it therefore does not matter for our results whether men or women propose. Yet, for sake of simplicity, in our description of the algorithm we assume that it is men who propose:

(1) Each man who is not engaged (or, in the terminology of Gale and Shapley (1962), 'matched') to a woman yet proposes to the woman who ranks highest in his list of alternatives. Any draw in this list is resolved randomly.

[1] In men and women value the same characteristics in partners, the highest-ranking man in terms of the valuable characteristics will match with the highest-ranking woman, the second-highest-ranking man will match with the second-highest-ranking woman, and so on. This is congruent with Bertrand et al.'s (2015) assertion that economic models predict that if men and women have a positive preference for income in their partners, the resulting marriages will be among people who are in the same percentile of the income distribution among the members of their own sex.

(2) Each woman considers the proposals that she has received and:

(2.1) If she is not matched to a man yet, she accepts the proposal of the man she prefers most, so that they get matched. She rejects the proposals by all other men and is removed from the rejected men's lists of alternatives.

(2.2) If she is matched already, she keeps the proposal from the man she prefers most and rejects all other proposals. She then compares the utility she derives from her current partner with the utility she would derive from the proposing man. If the utility that she derives from her current partner is equal to or higher than that of the proposing man, she rejects the proposal. However, if the utility of the proposing man is higher, the woman un-matches from her current partner and matches with the proposing man. The woman is then removed from the rejected men's lists of alternatives.

These steps are repeated until all men are matched or have exhausted their list of alternatives.[2]

We have applied the GS-algorithm to the 27 national marriage markets that we consider here. Given that agents are assigned their income probabilistically, and given that draws in their alternatives lists are resolved randomly, we have conducted 25 independent simulation runs per country, and averaged outcomes across runs within countries. Figure 3 shows the results of this simulation experiment and compares the simulated distributions of relative income with the empirically observed distributions. The results that the simulation model generates tend to trace the observed patterns closely in the left-hand part of the distributions, where women contribute relatively little to household incomes. However, across countries, the simulation model tends to create a peak close to the point where women contribute about 40% of the household income. After this peak, the distributions tend to drop quickly again, and in most countries, there are very few unions in which the wife earns more than the husband. This is exemplified by the results for Norway. In both the simulation outcomes and the empirically observed data, the share of couples increases steadily from the point where women contribute almost nothing to household income, up to the point where they contribute about 30%. From this point onwards, the couple shares that the simulation model generates rise rapidly and reach about 42% at the point where women contribute about 40% of the household income. After this, the simulated distribution drops sharply, and there are almost no couples where the wife contributes more than 50%. Thus, compared to the observed data, the GS-algorithm creates

[2] Members of the proposing sex can exhaust their list of alternatives before being matched if the sex-ratio is imbalanced so that there is a shortage of opposite-sex members.

relative-income distributions that are even more skewed than observed empirically. Most importantly, the model generates a discontinuity but this discontinuity occurs already at the 40/60 point, rather than at 50/50.

–Figure 3 about here–

Sequential partner search (Extension 1)

The GS-algorithm assumes that partner search takes place on a perfect market. There are no search frictions, no search costs, and everybody has full information about all the available alternatives. In reality, the search for a spouse is a sequential and costly process and is subject to incomplete information and uncertainty (Weiss 1997). That is, instead of having knowledge about the characteristics of all members of the marriage market, people often need to invest effort to meet opposite-sex members and to learn about their characteristics. Research in the wake of Gale and Shapley (1962) has incorporated these features of real marriage markets in more complex partner search models (e.g., Adachi 2003; Lee 2009).

In these more complex models, the central question is 'how should people decide when to stop their search?'. If men and women cannot be sure who they will meet in the future, they need to somehow trade off the utility from marrying one of the currently available alternatives vs. the utility they may derive from finding somebody even more attractive in the future, net of the costs that prolonged search creates. This problem can be solved by determining people's *reservation quality*, which is the minimal quality that a given man or women should aspire for in a partner; they should stop their search when they find a partner whose quality is equal to or higher than this value. The reservation quality can be calculated based on information about the composition of the marriage market (i.e., how likely is it that people will meet very attractive alternatives?), about the characteristics of the focal individual (i.e., how attractive is the person for opposite-sex members?), and the distribution of characteristics among the members of the own sex (i.e., how fierce is the competition?). In this way, even if not everybody will always find the best possible partner, people can expect that the utility of the partner that they select is likely to balance their search costs.

As several scholars have pointed out, the reservation quality is useful to determine how people should behave if they would conduct their partner search in a perfectly rational manner, but the calculations that are necessary for this are often too complex to be applied by the average person in real life (e.g., Todd et al. 2005, 2013). Instead, people tend to apply decision rules and heuristics that are much simpler, but that still tend to yield satisfactory outcomes. In particular, research in sociology and social psychology suggests that people tend to use their own quality as a point of reference, without engaging in explicit calculations to determine their optimal reservation quality (e.g., Townsend 1989; Sloman and Sloman 1988; Kenrick et al. 1993; Penke et al. 2007; Todd et al. 2013). This approach tends to be efficient because of the two-sided nature of partner search. People who have high quality characteristics are in high demand and therefore have good chances of attracting partners who also are of high quality. They can therefore afford to set their aspirations high and still find a partner with reasonable search effort. People with characteristics that are in lower demand, by contrast, are likely to experience more difficulties in attracting high quality partners. They therefore often need to set their aspirations lower, to avoid engaging in excessive search efforts that, in the worst case, might not lead to marriage (Penke et al. 2007).

To reflect the notions that (1) partner search is a sequential process and that (2) people tend to use their own qualities as a point of reference for partner selection, we have adjusted the original GS-algorithm in the following way. In line with Gale and Shapley (1962), we assume that men and women prefer marriage over being single, but we also assume that they aspire to partners whose income is at least as high as their own. Hence, as long as a given male or female agent is single, or is matched to somebody whose income is lower than their own, they actively search for a (better) partner. By contrast, agents who are matched to somebody who earns at least as much as they do cease their search. It is important to note that these preferences are gender-symmetrical in the model. That is, both men and women are content with a situation in which their partner earns as much as or more than they do. They are not more aversive of a situation in which the wife earns more than the husband than they are of a situation in which he out-earns her (as would be implied by a male-breadwinner norm). The actual search process consists of the following sequence of steps:

(1) Determine for each man and woman whether they are actively looking for a partner. This is the case when they are single, or when they are matched to somebody who earns less than they do.

(2) Randomly pair all men who are looking for a partner with exactly one woman who is also looking for a partner (some men or women might not be paired if their numbers are imbalanced). Within each pair, both agents determine whether they want to signal to the other agent that they want to start a relation with them. These decisions are based on the following rules:

(2.1) If a given agent is single, they always indicate that they are willing to start a relation with the agent they have been paired with.

(2.2) If a given agent is already in a relation, they signal that they are willing to start a relation with the agent they have been paired with if the income of the alternative is higher than that of their current partner.

(3) For all pairs in which both agents have indicated that they are willing to form a relation, break relations with possible current partners and let them start a relation with each other; dissolve all other pairings.

These steps are repeated for up to a number of *I* iterations.

As for the GS-algorithm, we have applied the sequential search model to conduct 25 separate simulation runs in each of the 27 countries and averaged results across runs. In this experiment, we set *I* to 20. Figure 4 shows the outcomes of this simulation experiment. As the figure illustrates, the distributions of relative income that this model generates resemble those that we have obtained from the GS-algorithm, but they are closer to the empirically observed distributions. In particular, the peaks in the relative-income distributions are close to the 50/50 demarcation line. After this point, there usually is a sharp drop and there are very few marriages where the wife earns more than the husband. Also, compared to the GS-algorithm, the shares of marriages where the wife earns more than her husband are higher and they are closer to the empirically observed values.

Why does the sequential search model generate this sharp drop at the 50/50 point? Earlier simulation research has shown that the competitive pressures that a universal preference for high quality partners creates leads to matchings that show a high correlation in partner quality (e.g., Kalick and Hamilton 1986). In our model, this fact tends to create a heaping of unions close to the 50/50 point in terms of relative income. Yet, given that women tend to earn less than men, men are more likely to encounter women who earn less than they do, rather than women who earn more. This increases the likelihood that those unions in which partners differ in their incomes will be on the left-hand side of the 50/50 point, thereby creating a 'cliff' in the distribution.

Taken together, our results suggest that the income cliff can emerge even if both women *and* men desire partners who earn as much as or even more than they do. This preference structure is in stark contrast with the structure that a male-breadwinner norm would imply, namely that only women would prefer partners with equal or higher income, whereas men would prefer partners with equal or lower income.

–Figure 4 about here–

Sequential search when a partner is present (Extension 2)

In the model that considers sequential search, agents who have found a partner that meets their aspirations cease their search completely, whereas agents who do not have found such a partner yet continue their search with full effort. In reality, for most people it will not be possible to continue their search for a partner with full effort when they already are in a relation. This is partly because spending time with their partner reduces the time that is available for searching for an alternative, but also because active search puts the current relation at risk even is no alternative is available yet (Simão and Todd 2003; Stauder 2006). Conversely, even people who are very satisfied with their current partner might sometimes encounter more attractive alternatives accidentally during their daily activities (e.g., at work) (Grow et al. forthcoming; South et al. 2001; McKinnish 2004). To incorporate these aspects of partner search into the sequential search model, we have introduced the parameters α ($0 \leq \alpha \leq 1$) and β ($0 \leq \beta \leq 1$). These parameters govern the probability that agents who already are in a relation encounter possible alternatives in a given iteration. More specifically, α governs the probability that agents whose partner's income is lower than their own encounter a possible alternative (i.e., are available for being paired with an opposite-sex member in step (2) of the sequential search model described above), whereas β governs the probability that agents whose partner's income is equal to or higher than their own encounter a possible alternative.

Generally, we assume that $\beta < \alpha$ is plausible in most empirical situations. The reason is that even though both members of a union might have their time equally 'bound up' in their relation, their motivations for actively searching for a better alternative are likely to differ. In relations in which one member of the couple contributes more to the relation than the other (e.g., in terms of income) the partners are likely to notice this inequity and this can lead them to experience strains that reduce their satisfaction with their relation (Sprecher 1986, 1998). While both partners might experience such strain, the partner who is under-benefiting (i.e., who contributes relatively more) is likely to experience more strain than the partner who is over-benefiting (i.e., who contributes relatively less). The under-benefitting partner is therefore likely to be less satisfied with the relation and has a larger incentive to look for outside options (Sprecher 1986, 1992, 2001). It is important to note that also here we assume that these processes are gender-symmetrical. That is, we assume that both men and women who are in a relation with a partner who earns less than they do are more likely to search for a higher-income alternative than people who have a partner who earns as much as or more than they do.

Figure 5 shows the results of a simulation experiment in which the number of iterations (I) was set to 20, whereas α was set to .5, and β was set to .2. Across countries, the outcomes that the extended sequential search model generates come even closer to the empirically observed distributions than that of the simple sequential search model. For example, in Romania, the outcomes that the model generates closely trace the observed distribution of relative income. In some countries, the cliff in the relative-income distributions that the simulation model generates is still somewhat larger than observed empirically (e.g., in Greece). However, the distributions that the simulation model generates are qualitatively similar to those observed empirically and this is the case even if we do not assume that people evaluate a situation in which the wife earns more than the husband any differently than a situation in which the husband earns more.

–Figure 5 about here–

Discussion and conclusion

In this paper, we have explored whether it is necessary to assume a male-breadwinner norm to explain why there is a discontinuity in the distributions of the relative income that men and women contribute to their households. Earlier research has suggested that the observed discontinuity at the 50/50 point might indicate such a norm, meaning that both men and women would be aversive of a situation in which a wife would out-earn her husband. We have suggested that a discontinuity at the 50/50 point might emerge even if people would not attach special meaning to a situation in which a wife out-earns her husband and simply value high income in their partners. The reason for this is that there are differences in the average incomes of men and women. These differences limit men's opportunities to find partners who earn as much as or more than they do, whereas this is easier for women. We have explored the logical consistency of our argument with three different simulation models that differ in their assumptions about partner search. We found that each of these models can generate a discontinuity in the relative-income distribution to the advantage of men, without the need to assume that there is a male-breadwinner norm. Our results thus highlight the risks of inferring preferences and norms from observed marriage patterns. As Smaldino and Shank (2011) have pointed out, marriage markets are complex systems and different preference structures and behaviours at the individual level can lead to similar outcomes at the population level.

It is important to highlight that we do not claim that a male-breadwinner norm does not exist in at least some countries or in some parts of the population of a given country. Rather, our results suggest that such a norm might be *just one* of several pieces in the puzzle of income differences within heterosexual households. It is also important to highlight that our models are ‘minimal’ models, which describe a set of conditions that are *sufficient* to generate a discontinuity in the distributions of relative income across households. As such, the models abstract from some processes that might affect marriage patterns in real life. One crucial aspect that we have neglected here is that peoples’ incomes might be endogenous to the marriage process itself. In particular, both men and women tend to adjust their labour market behaviour as a result of marriage and the anticipation of children within their newly formed families. This is especially the case for women, who often reduce their working hours once children are anticipated, and who sometimes do not fully return to the labour force even after their offspring has left the parental home. If this is the case, the income data that underlies our simulations might be partly affected by the process of marriage itself, whereas we have treated income as exogenously given. As a consequence, our modelling approach is rather conservative: we find that differences in the incomes of men and women can lead to a discontinuity in the relative income distribution, even if we neglect potential intra-couple processes that might affect people’s incomes once a family has formed and thereby contribute to the empirically observed discontinuity.

Furthermore, we have neglected mechanisms that might contribute to similarity in partners’ incomes, net of any partner preferences and norms. In our simulations, we have focused on national marriage markets, but in reality people tend to select their partners from more local contexts. That is, people spend much of their time in their neighbourhoods, schools, and work places, and this increases the chance that they will meet prospective partners in these contexts. To the extent that people in these contexts resemble each other more in their socioeconomic backgrounds than any randomly selected members of the population this is likely to increase the similarity in income than can be observed within couples. Future research might extend our work to incorporate such more ‘local’ marriage markets in the simulation process and explore how this affects results.

Despite this need for future research, our results have important implications for theorizing about households in the light of changing gender norms. Over the last decades, many Western societies have moved towards more gender egalitarian attitudes (e.g., Zentner and Eagly 2015). Our results suggest that such attitudes might not translate into more egalitarian family structures, in particular when it comes to men’s and women’ contributions to the financial resources of their households, as long as there are systematic differences in the incomes of men and women.

References

Adachi, Hiroyuki. 2003. A search model of two-sided matching under nontransferable utility. *Journal of Economic Theory*, 113(2), 182–198.

Bailey, Martha J., & Diprete, Thomas A. 2016. Five decades of remarkable but slowing change in U.S. women's economic and social status and poplitical participation. *Russel Sage Foundation Journal of Sociology*, 2(4), 1–32.

Berscheid, Ellen, Dion, Karen, Walster, Elaine, & Walster, G. William. 1971. Physical attractiveness and dating choice: A test of the matching hypothesis. *Journal of Experimental Social Psychology*, 7(2), 173–189.

Bertrand, Marianne, Kamenica, Emir, & Pan, Jessica. 2015. Gender identity and relative income within households. *Quarterly Journal of Economics*, 130(2), 571–614.

Billari, Francesco C., Ongaro, Fausta, & Prskawetz, Alexia. 2003. Introduction: Agent-based computational demography. In F. C. Billari & A. Prskawetz (Eds.), *Agent-Based Computational Demography: Using Simulation to Improve our Understanding of Demographic Behaviour* (pp. 1–17). Heidelberg: Physica Verlag.

Cha, Youngjoo. 2013. Overwork and the persistence of gender segregation in occupations. *Gender & Society*, 27(2), 158–184.

England, Paula. 2004. More mercenary mate selection? Comment on Sweeney and Cancian (2004) and Press (2004). *Journal of Marriage and Family*, 66(4), 1034–1037.

England, Paula. 2010. The gender revolution: Uneven and stalled. *Gender & Society*, 24(2), 149–166.

England, Paula, & Farkas, George. 1986. *Households, Employment, and Gender: A Social, Economic, and Demographic View*. Hawthorne: Aldine Publishing Co.

Esping-Andersen, Gøsta. 2009. *The Incomplete Revolution: Adapting to Women's New Roles*. Cambridge: Polity Press.

Esteve, Albert, García-Román, Joan, & Permanyer, Iñaki. 2012. The gender-gap reversal in education and its effect on union formation: The end of hypergamy? *Population and Development Review*, 38(3), 535–546.

Gale, David, & Shapley, Lloyd S. 1962. College admissions and the stability of marriage. *The American Mathematical Monthly*, 69(1), 9–15.

Goldscheider, Frances, Bernhardt, Eva, & Lappegård, Trude. 2015. The gender revolution: A framework for understanding changing family and demographic behavior. *Population and Development Review*, 41(2), 207–239.

Grow, André, Schnor, Christine, & Van Bavel, Jan. (Forthcoming). The reversal of the gender gap in education and relative divorce risks: A matter of alternatives in partner choice? *Population Studies*.

Grow, André, & Van Bavel, Jan. 2015. Assortative mating and the reversal of gender inequality in education in Europe: An agent-based model. *PLoS ONE*, 10(6), e0127806.

Hiekel, Nicole, Liefbroer, Aart C., & Poortman, Anne Rigt. 2014. Understanding diversity in the meaning of cohabitation across Europe. *European Journal of Population*, 30(4), 391–410.

Jalovaara, Marika. 2012. Socio-economic resources and first-union formation in Finland, cohorts born 1969–81. *Population Studies*, 66(1), 69–85.

Kalick, S.Michael, & Hamilton, Thomas E. 1986. The matching hypothesis reexamined. *Journal of Personality and Social Psychology*, 51(4), 673–682.

Kenrick, Douglas T., Groth, Gray E., Trost, Melanie R., & Sadalla, Edward. 1993. Integrating evolutionary and social exchange perspectives on relationships: Effects of gender, self-appraisal, and involvement level on mate selection criteria. *Journal of Personality and Social Psychology*, 64(6), 951–969.

Klesment, Martin, & Van Bavel, Jan. 2017. The reversal of the gender gap in education, motherhood, and women as main earners in Europe. *European Sociological Review*, 33(3), 465–481.

Lee, Soohyung. 2009. Marriage and online mate-search services: Evidence from South Korea. Unpublihsed working paper.

McKinnish, Terra G. 2004. Occupation, sex-integration, and divorce. *The American Economic Review*, 94(2), 322–325.

Oppenheimer, Valerie Kincade. 1988. A theory of marriage timing. *American Journal of Sociology*, 94(3), 563–591.

Penke, Lars, Todd, Peter M., Lenton, Alison P., & Fasolo, Barbara. 2007. How self-assessments can guide human mating decisions. In G. Geher & G. Miller (Eds.), *Mating Intelligence: Sex, Relationships, and the Mind's Reproductive System* (pp. 37–76). New York: Psychology Press.

Ridgeway, Cecilia L. 2011. *Framed by Gender: How Gender Inequality Persists in the Modern World*. Oxford: Oxford University Press.

Schofer, Evan, & Meyer, John W. 2005. The worldwide expansion of higher education in the twentieth century. *American Sociological Review*, 70(6), 898–920.

Simão, Jorge, & Todd, Peter M. 2003. Emergent patterns of mate choice in human populations. *Artificial Life*, 9(4), 403–417.

Sloman, Steven, & Sloman, Leon. 1988. Mate selection in the service of human evolution. *Journal of Social and Biological Structures*, 11(4), 457–468.

Smaldino, Paul E., & Schank, Jeffrey C. 2011. Human mate choice is a complex system. *Complexity*, 17(5), 11–22.

South, Scott J., Trent, Katherine, & Shen, Yang. 2001. Changing partners: Toward a macrostructural-opportunity theory of marital dissolution. *Journal of Marriage and Family*, 63(3), 743–754.

Sprecher, Susan. 1986. The relation between inequity and emotions in close relationships. *Social Psychology Quarterly*, 49(4), 309–321.

Sprecher, Susan. 1992. How men and women expect to feel and behave in response to inequity in close relationships. *Social Psychology Quarterly1*, 55(1), 57–69.

Sprecher, Susan. 1998. Social exchange theories and sexuality. *The Journal of Sex Research*, 35(1), 32–43.

Sprecher, Susan. 2001. Equity and social exchange in dating couples: Associations with satisfaction, commitment, and stability. *Journal of Marriage and Family*, 63(3), 599–613.

Stauder, Johannes. 2006. Die Verfügbarkeit partnerschaftlich gebundener Akteure für den Partnermarkt [The availability of actors with a partner on the partner market]. *Kölner Zeitschrift fur Soziologie und Sozialpsychologie*, 58(4), 617–637.

Sweeney, Megan M., & Cancian, Maria. 2004. The changing importance of white women's economic prospects for assortative mating. *Journal of Marriage and Family*, 66(4), 1015–1028.

Todd, Peter M., Billari, Francesco C., & Simão, Jorge. 2005. Aggregate age-at-marriage patterns from individual mate-search heuristics. *Demography*, 42(3), 559–574.

Todd, Peter M., Hills, Thomas, & Hendrickson, Andrew. 2013. Modeling reproductive decisions with simple heuristics. *Demographic Research*, 29, 641–662.

Torr, Berna M. 2011. The changing relationship between education and marriage in the United States, 1940-2000. *Journal of Family History*, 36(4), 483–503.

Townsend, John Marshall. 1989. Mate selection criteria: A pilot study. *Ethology and Sociobiology*, 10(4), 241–253.

Van Bavel, Jan, & Grow, André. 2016. Introduction: Agent-based modelling as a tool to advance evolutionary population theory. In A. Grow & J. Van Bavel (Eds.), *Agent-Based Modelling in Population Studies: Concepts, Methods, and Applications* (pp. 3–27). Cham: Springer International Publishing.

Weiss, Yoram. 1997. The formation and dissolution of families: Why marry? Who marries whom? And what happens upon divroce? In M. R. Rosenzweig & O. Stark (Eds.), *Handbook of Population and Family Economics* (pp. 81–123). Amsterdam: Elsevier Science B.V.

Willekens, Frans. 2010. Family and household demography. In Y. Zeng (Ed.), *Demography - Volume II* (pp. 86–112). Oxford: Eolss Publishers.

Zentner, Marcel, & Eagly, Alice H. 2015. A sociocultural framework for understanding partner preferences of women and men: Integration of concepts and evidence. *European Review of Social Psychology*, 26(1), 328–373.

Zinn, Sabine. 2016. Simulating synthetic life courses of individuals and couples, and mate matching. In A. Grow & J. Van Bavel (Eds.), *Agent-Based Modelling in Population Studies: Concepts, Methods, and Applications* (pp. 113–157). Cham: Springer International Publishing.

Figures

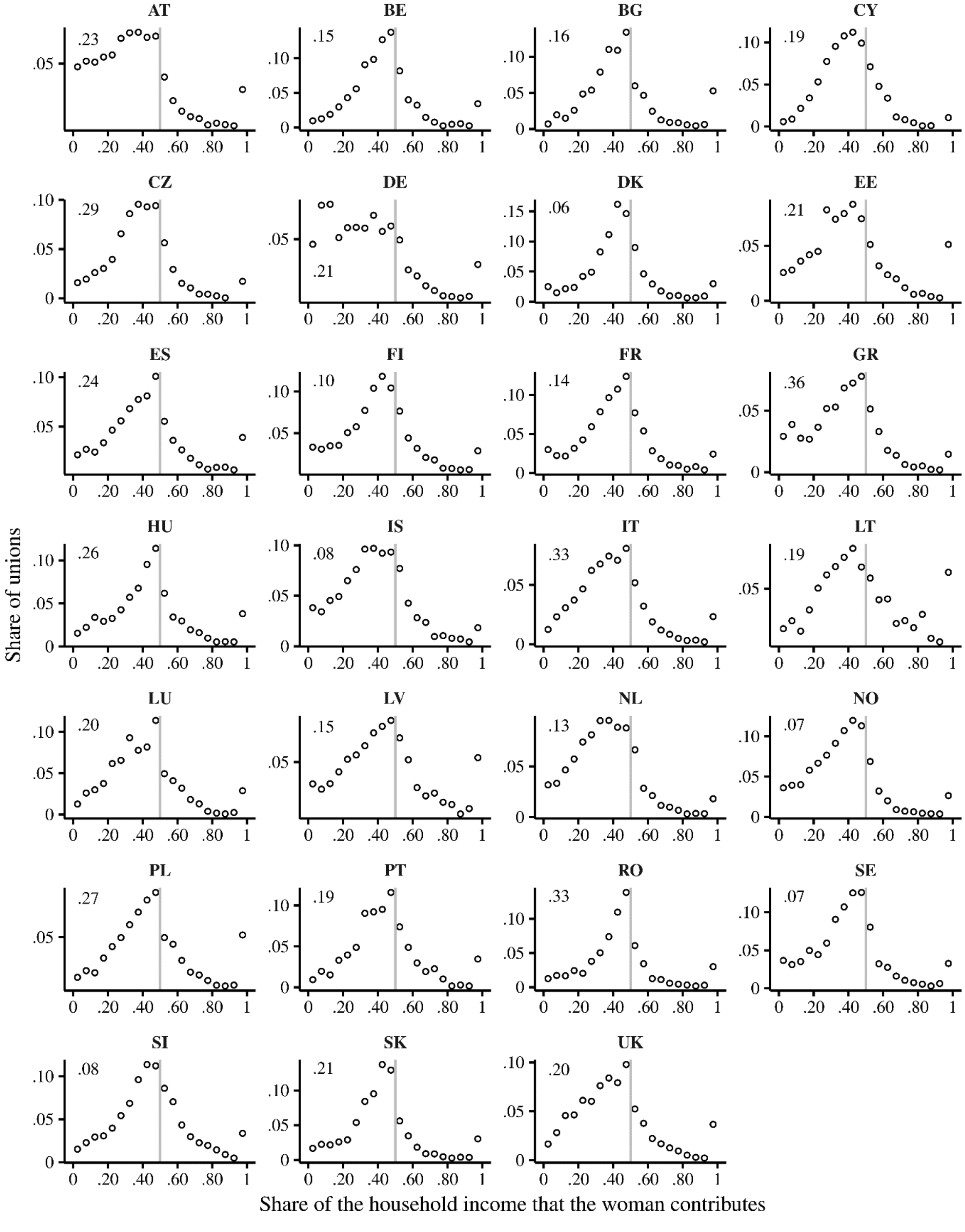

Figure 1 Shares that women contribute to household income in 27 countries

Note: The share that the woman provides to household income is calculated as $y_w/(y_w+y_m)$, where y_w and y_m refer to the income of the woman and the man, respectively. The grey vertical line indicates the point where the share of the household income that the woman provides is .5. The number in the upper left corner of each panel shows the share of couples in which the woman contributes nothing to household income.

Source: Pooled data from the 2007 and 2011 waves of the cross-sectional versions of the European Union Statistics on Income and Labour Conditions (EU-SILC). We have selected women who were married or living in unmarried cohabitation with a male partner at the time of the survey, and who were 25–45 years old and had a partner in the same age range. We only selected unions in which at least one partner had positive, non-zero income. The income reference year is the year prior to the survey, so that the income data pertain to the years 2006 and 2010. Sampling weights have been applied.

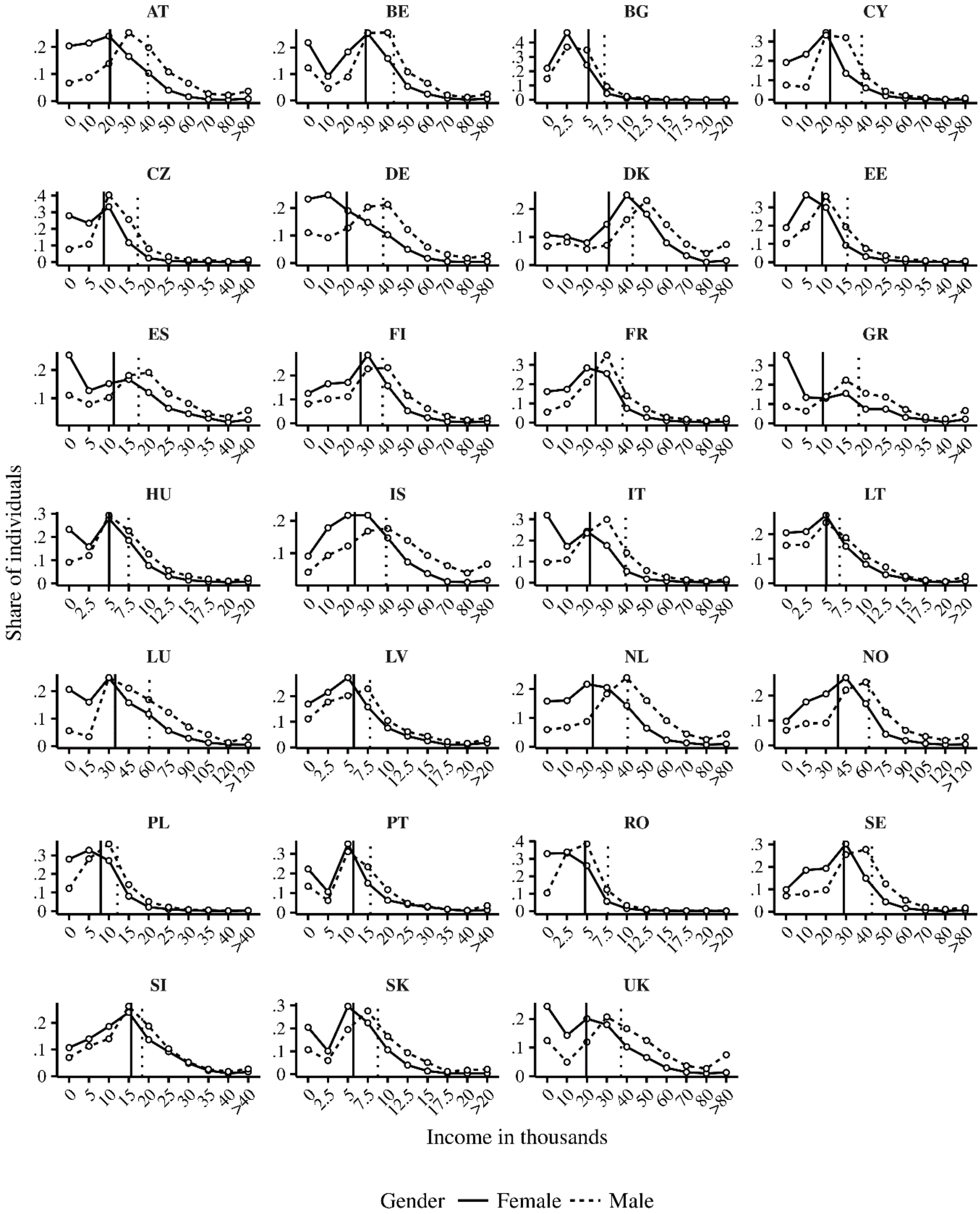

Figure 2 Comparison of women’s and men’s incomes across 27 countries

Note: Income was measured in national currencies. The vertical lines show the average incomes of men and women.

Source: Pooled data from the 2007 and 2011 waves of the cross-sectional versions of the European Union Statistics on Income and Labour Conditions (EU-SILC). We have selected all men and women who were 25–45 years old and who had zero or non-negative income. The income reference year is the year prior to the survey, so that the income data pertain to the years 2006 and 2010. Sampling weights have been applied.

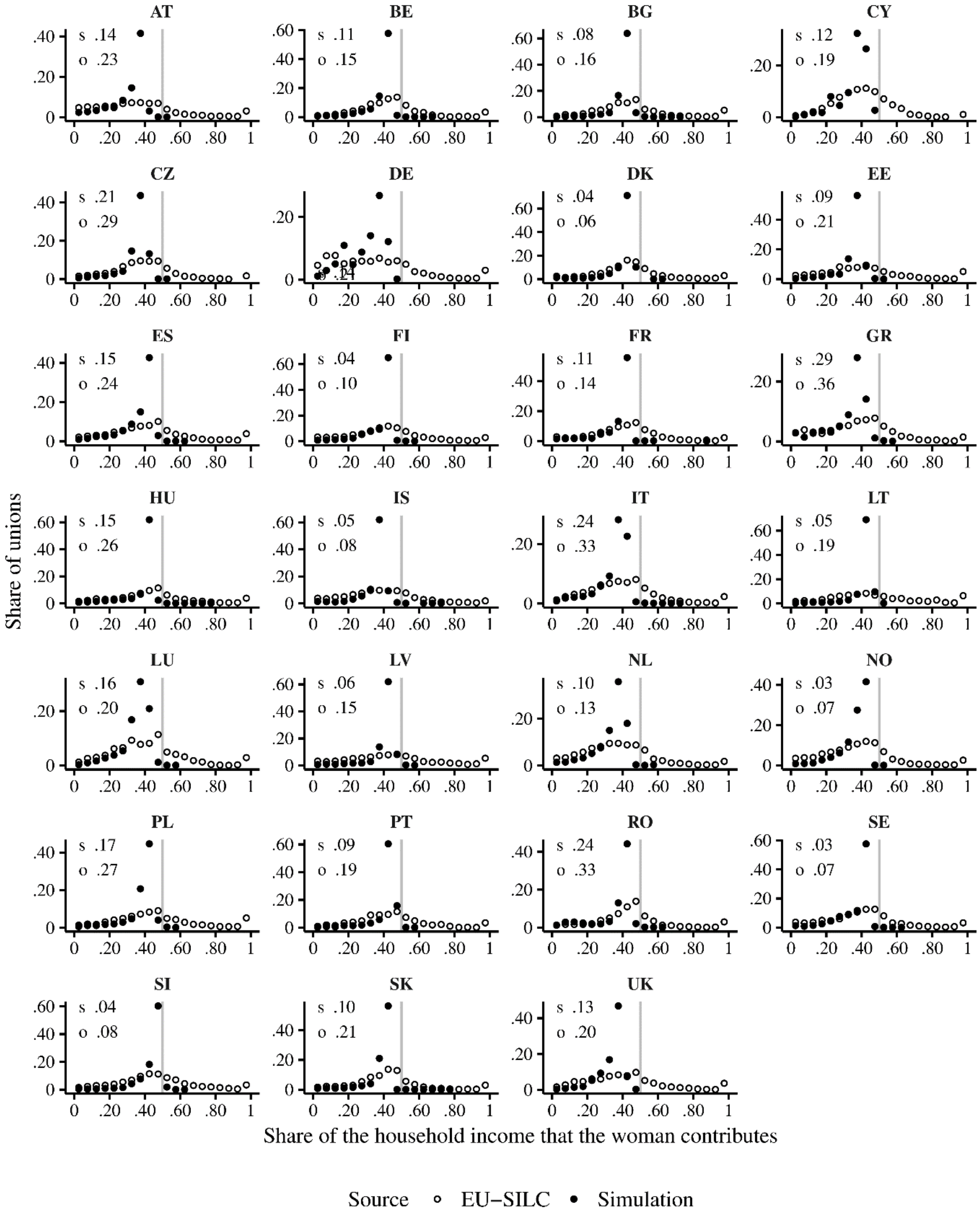

Figure 3 Comparison of the relative-income distributions observed in the EU-SILC data with those generated by the GS-algorithm

Note: The share that the woman provides to household income is calculated as $y_w/(y_w+y_m)$, where y_w and y_m refer to the income of the woman and the man, respectively. The grey vertical line indicates the point where the share of the household income that the woman provides is .5. The numbers in the upper left corner of each panel show the shares of couples in which the woman contributes nothing to the household income, as obtained from the simulations ('s') and observed ('o') in the empirical data.

Source: The simulation results are based on our simulation experiments with the GS-algorithm. The empirical data are the same as for Figure 1.

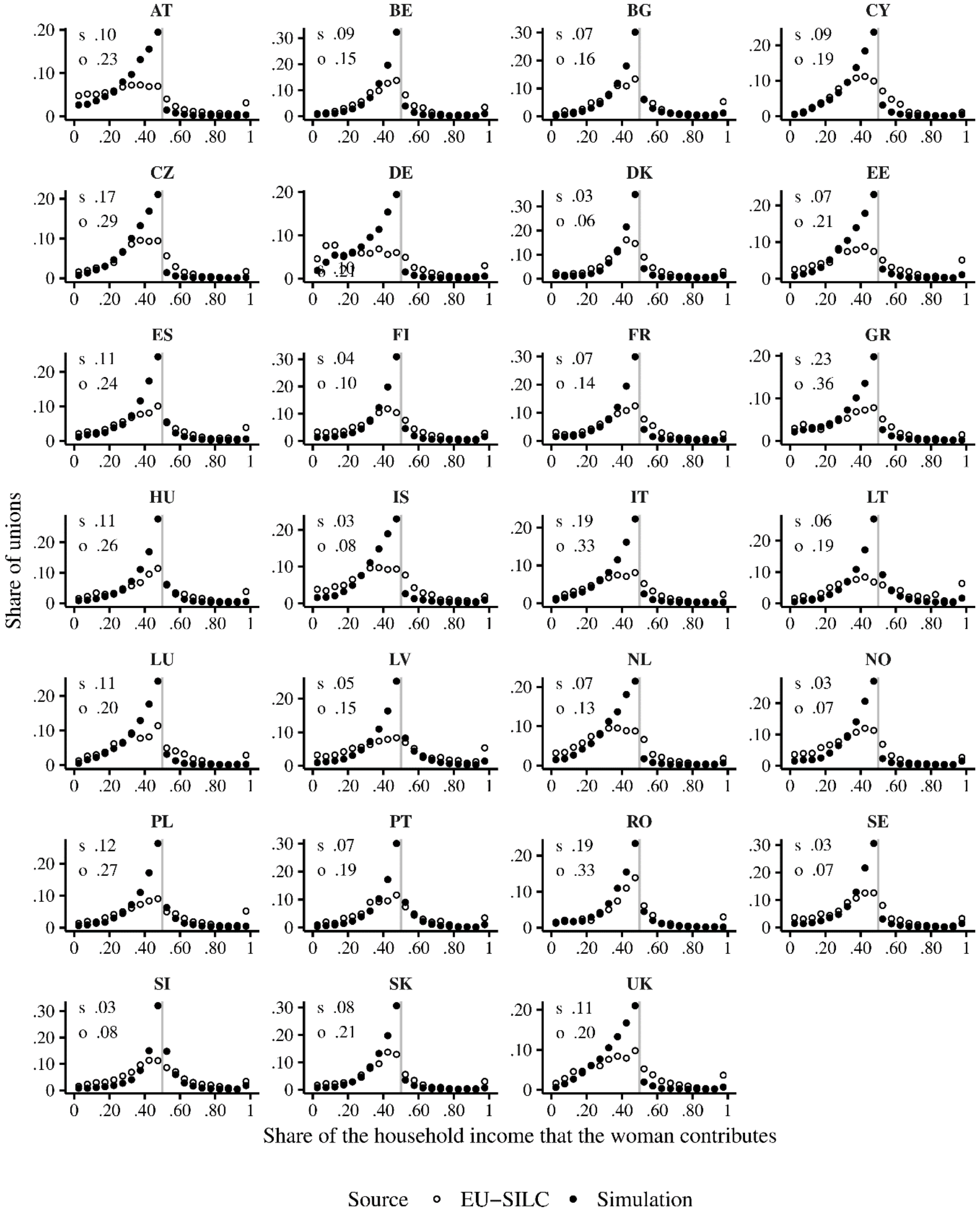

Figure 4 Comparison of the relative-income distributions observed in the EU-SILC data with those generated by the sequential search model (Extension 1)

Note: The share that the woman provides to household income is calculated as $y_w/(y_w+y_m)$, where y_w and y_m refer to the income of the woman and the man, respectively. The grey vertical line indicates the point where the share of the household income that the woman provides is .5.

The numbers in the upper left corner of each panel show the shares of couples in which the woman contributes nothing to the household income, as obtained from the simulations (‘s’) and observed (‘o’) in the empirical data.

Source: The simulation results are based on our simulation experiments with the sequential search model (Extension 1). The empirical data are the same as for Figure 1.

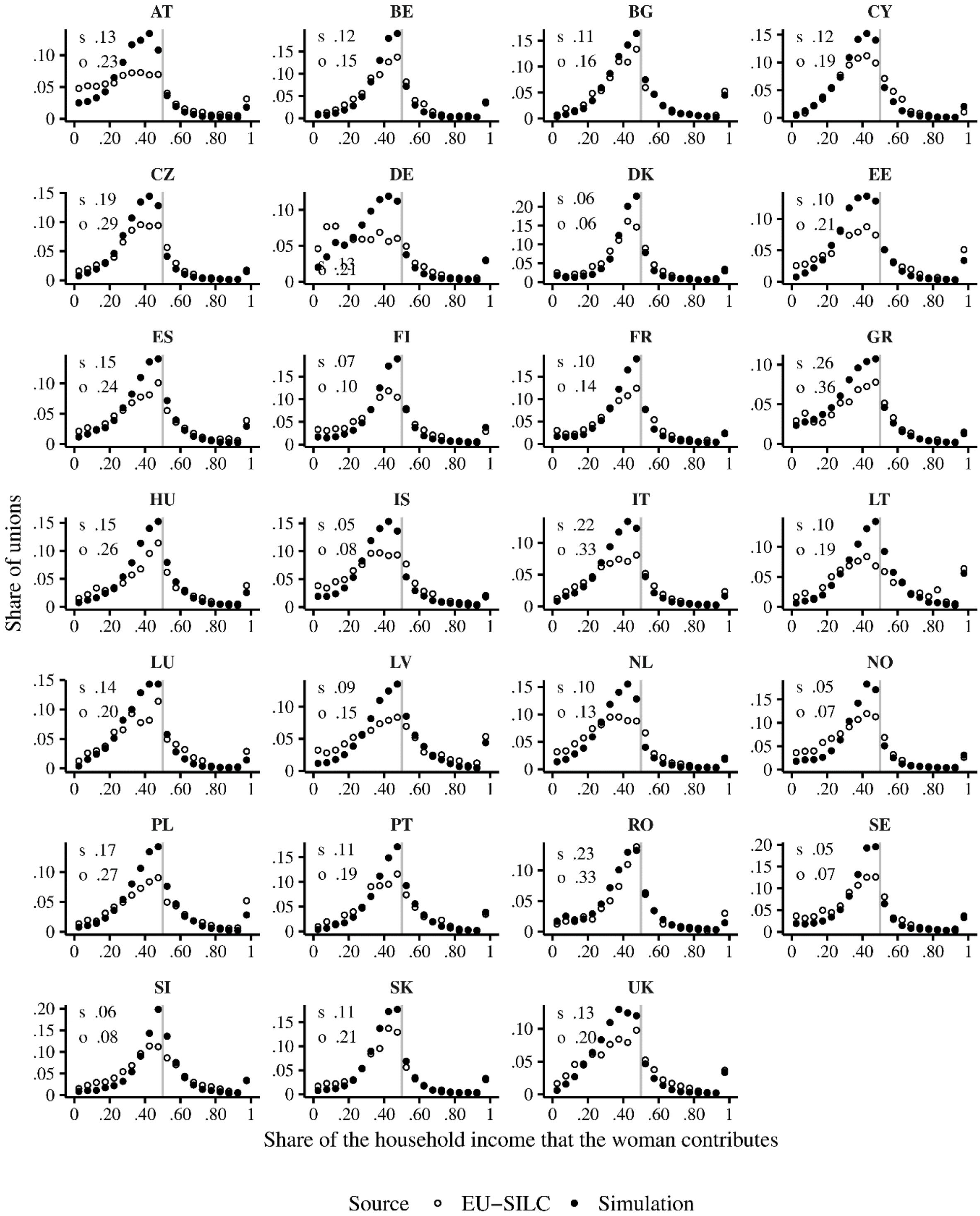

Figure 5 Comparison of the relative-income distributions observed in the EU-SILC data with those generated by the sequential search model that considers changes in partner search behaviour when a partner is present (Extension 2)

Note: The share that the woman provides to household income is calculated as $y_w/(y_w+y_m)$, where y_w and y_m refer to the income of the woman and the man, respectively. The grey vertical line indicates the point where the share of the household income that the woman provides is .5.

The numbers in the upper left corner of each panel show the shares of couples in which the woman contributes nothing to the household income, as obtained from the simulations ('s') and observed ('o') in the empirical data.

Source: The simulation results are based on our simulation experiments with the sequential search model, considering that people's search behavior changes when they are already in a relation (Extension 2). The empirical data are the same as for Figure 1.